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Increasing Water Efficiency by Using Fuzzy Logic Control in Tomatoes Seedling Cultivation

Selami Kesler[1], Abdil Karakan[2*] and Yüksel Oğuz [3]

[1] *Electrical and Electronics Engineering, Pamukkale Universty, Denizli, Turkey, (skesler@pau.edu.tr) (Orcid ID: 0000 0002 7027 1426)*
[*2] *Electrical Department, Afyon Kocatepe Universty,Afyonkaraisar, Turkey, (akarakan@aku.edu.tr), Orcid ID: 0000 0003 1651 7568)*
[3] *Electrical and Electronics Engineering, Afyon Kocatepe Universty, Afyonkarahisar, Turkey, (ykseloguz@aku.edu.tr), Orcid ID: 0000-0002-5233-151X)*

Abstract – The biggest problem in agriculture is the insufficient amount of water. Sowing cannot be done in the fields due to water scarcity. Some fields become barren land due to excessive irrigation. For these reasons, it is important to use water wisely. In the study, irrigation of tomatoes seed is controlled with fuzzy logic. The use of water is made automatically according to the humidity, temperature and soil moisture of the air. The study was carried out in two stages. First stage; The irrigation system is designed in the MATLAB program. For this, temperature, humidity and soil moisture were used as three inputs. Irrigation time was calculated as output. All inputs and outputs are set to low, medium and high. In the second stage; equal amounts of tomatoes seeds were planted in two separate containers. Normal irrigation was done in the first pot. The control of irrigation in the second bowl was made with fuzzy logic. All data are shown on the screen and recorded for 1 minute. As a result of the study, 22500 milliliters of water were used in normal irrigation, and 10410 milliliters of water were used in a fuzzy logic-controlled circuit. As a result, a water saving of 53.77% was achieved. Arduino microcontroller is used for control. The code was written for the fuzzy logic control circuit simulated in the Arduino microcontroller MATLAB program to work. At the same time, temperature and humidity sensors are connected to the Arduino microcontroller. Incoming data is remotely monitored and controlled by a modem connected to the microcontroller. When the records in the database are examined, 83% energy was saved with lighting algorithm and energy flow control algorithms.

Keywords *– Fuzzy logic, Productivity, Tomato seedling, Remote control*

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I. Introduction

The most important food source of people is agricultural products. Some agricultural lands become arid with excessive irrigation and some cannot be irrigated due to water scarcity. Efforts are being made to overcome the problems occurring in agriculture [1]. In the study of Khandere and his friends; They made an irrigation system based on solar energy. Their main purpose is low-cost and time-based irrigation. The control of the selonid valve in the irrigation system was carried out automatically [2]. In the study by Parameswaran et al. Ambient temperature, humidity and soil moisture were measured. Arduino microcontroller is used in this measurement. The irrigation system was carried out manually according to the data from the sensor [3]. Rehman et al. Controlled the irrigation system on a GSM basis in their study. In their systems, temperature, humidity and soil moisture have been measured with sensors. Data from the sensors are shown on GSM. Irrigation control is performed with the data coming from GSM [4]. Venkatapur et al used temperature, humidity and soil moisture sensors. The data from the sensors are connected to the Arduino microcontroller. Raspberry is connected with Arduino via ZigBee. The opening and closing of the irrigation valve were through raspberry [5]. Zhang et al. carried out an application study in a region in the north-west of China. In this study, they aimed to increase irrigation efficiency. They also aimed to reduce salinization accumulations. They used fuzzy logic controller in their work. The study was done in simulation. As a result of the study, suitable solution plans for irrigation planning were presented [6]. Honorato tried to reduce the water consumption used in tulip production in his study. For this, fuzzy logic control, which is the most ideal method, is used. He tried to adjust the irrigation time with temperature control for the consumption of water in tulip production. As a result of the study, it has succeeded in reducing water consumption significantly [7]. Ehsan worked on a surface irrigation system. In this study, it was aimed to increase irrigation efficiency. He also worked on increasing productivity and efficiency with this study. SIRMOD and WinSRFR simulation programs were used in the study. As a result of this study, labor has been reduced by 10%. It also increased practicality by 9% and performance by 13% [8]. Perea et al. have worked on pressurized irrigation systems. In these studies, they aimed to reduce water consumption. His work was based on data used in a site located in the south-west of Spain. As a result of the study, a decrease of 19.5% was achieved in water consumption [9].

In the study, firstly, fuzzy control was designed in MATLAB simulation program. For this, three inputs and one output were created. Inputs are temperature, humidity, and soil moisture. Output is the irrigation time. Each variable is set to low, medium and high. Second, the real application has been made. Two containers were used for this. Equal amount of soil was placed in two containers and tomatoes seeds were planted. Outdoor temperature and humidity AHT10 sensor were measured. Humidity sensor is used to measure soil moisture. Normal irrigation was done in one. In the second bowl, irrigation was done with fuzzy logic. The irrigation result has been compared.

II. Materials and Method

The main purpose of the study is to increase water efficiency in tomatoes seedling cultivation with fuzzy logic control. Thus, less water will be used. The general scheme of the study performed is shown in Figure 1.

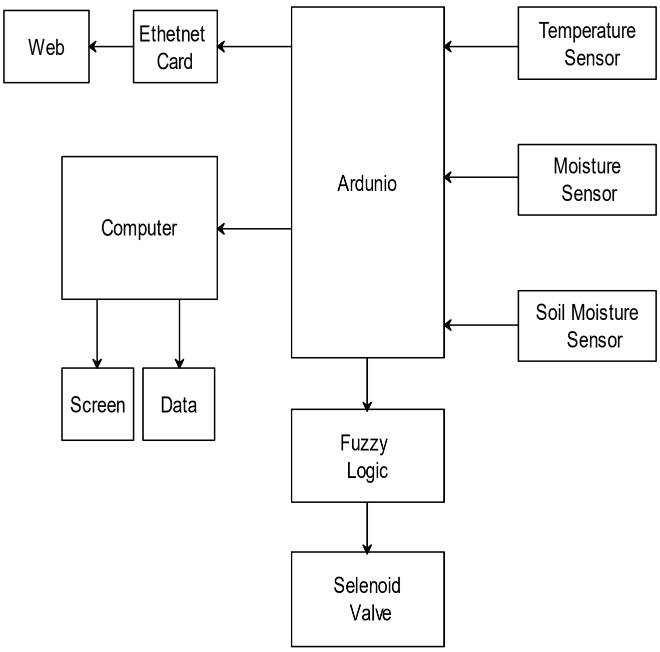


Fig. 1. General Scheme

A. Fuzzy Logic

Three factors necessary for the cultivation of tomatoes seed; temperature, humidity and soil moisture were taken as inputs. The output is the irrigation time. All input and output are named low, medium and high. The fuzzy logic architecture is shown in Figure 2.

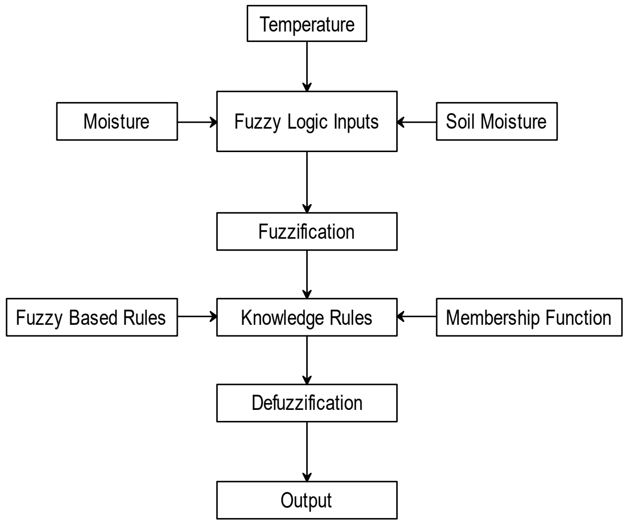


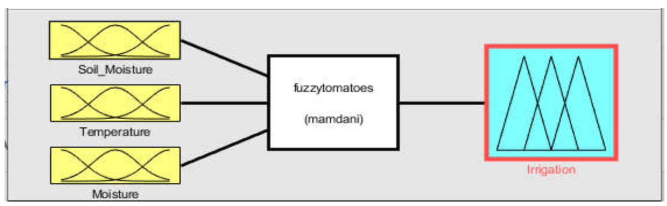
Fig. 2. *Fuzzy logic architectural*

In order for fuzzy logic to take a decision, the rules must be uploaded to the system. Table 1 shows the rules designed for the system. The table shows three inputs and one output.

Table 1. Fuzzy logic rules

Soil Moisture	Moisture	Temperature	Watering
Low	Low	Low	High
Low	Low	Normal	Normal
Low	Low	High	Normal
Low	Normal	Low	High
Low	Normal	Normal	Normal
Low	Normal	High	Low
Low	High	Low	High
Low	High	Normal	High
Low	High	High	Normal
Normal	Low	Low	Normal
Normal	Low	Normal	Normal
Normal	Low	High	Low
Normal	Normal	Low	Normal
Normal	Normal	Normal	Normal
Normal	Normal	High	High
Normal	High	Low	Normal
Normal	High	Normal	Low
Normal	High	High	Low
High	Low	Low	Low
High	Low	Normal	Low
High	Low	High	Low
High	Normal	Low	Low
High	Normal	Normal	Low
High	Normal	High	Low
High	High	Low	Low
High	High	Normal	Low
High	High	High	Low

All inputs and outputs are loaded in the MATLAB simulation program to provide fuzzy logic control. Soil moisture is shown in Figure 3.



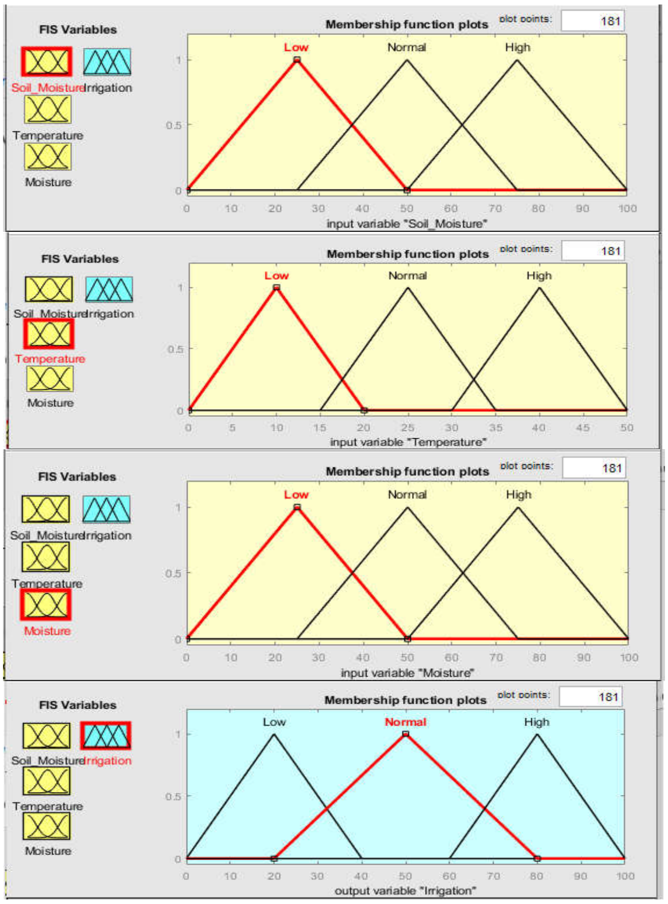


Fig. 3. *Soil moisture, temperature, moisture, irrigation*

Temperature, humidity and soil moisture inputs and irrigation time inputs were made. While making these entries, the time and amount of irrigation were determined with the rules. Irrigation is not done especially in hot weather. Irrigation is effective when temperatures are low. This is in the early morning or evening hours. Figure 4 shows the fuzzy logic control output.

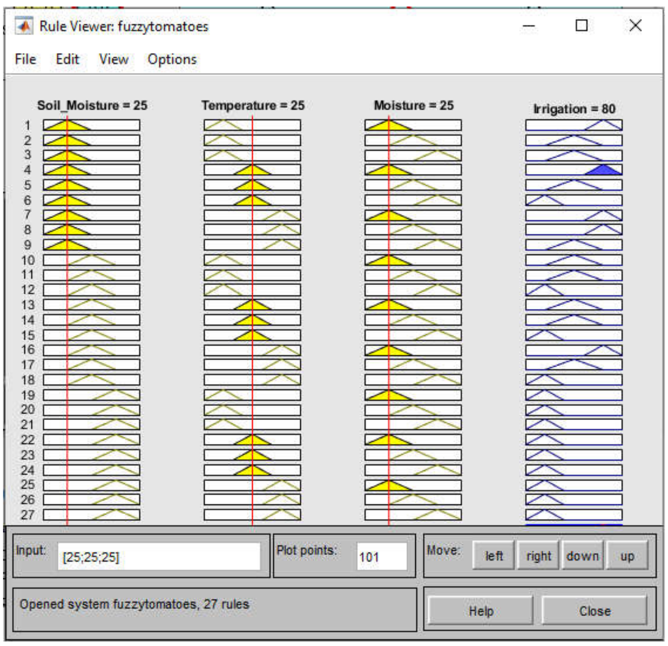


Fig. 4. *Fuzzy logic*

B. *Ardunio Microcontroller*

The system has two components. One is the MATLAB simulation part and the other is the part where the control system takes place. The control part takes place with the Arduino microcontroller. Temperature, humidity and soil moisture sensors are connected to the Arduino microcontroller. Fuzzy control works with the data from these sensors, and the tomatoes seedlings are irrigated accordingly. The control of the irrigation pump is provided by the relay. During the irrigation period, the relay is working and when the time is over, the relay stops. Thus, the irrigation pump is controlled. Figure 5 shows the control part designed for the system.

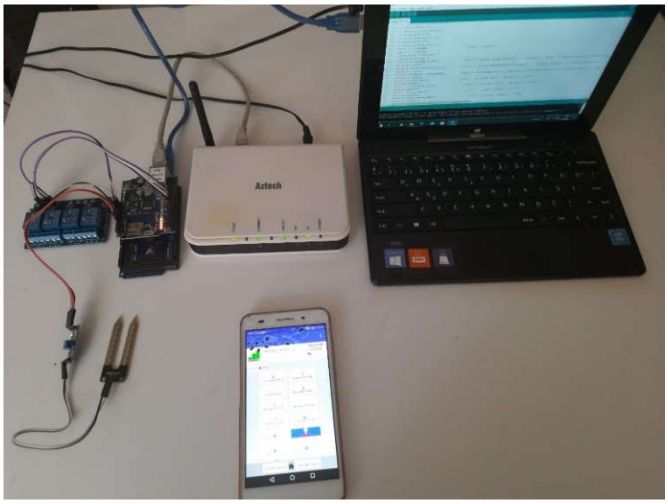


Fig. 5. Designed for system ardunio control

An Ethernet module was added to the Arduino microcontroller and wireless broadcast was made via the modem. Thus, remote access was provided. All data in the system could be monitored with all devices with Wi-Fi broadcast capability.

III. RESULTS

The applied system covers a period of 15 days. At this time, the tomatoes seedling was planted in two half-pots. Figure 7 shows the containers.

Fig. 6. *Daily highest and smallest temperature*

One was normal irrigation. The other container was irrigated with fuzzy control. Figure 7 shows the lowest and highest temperatures that occur during the seedling growing period.

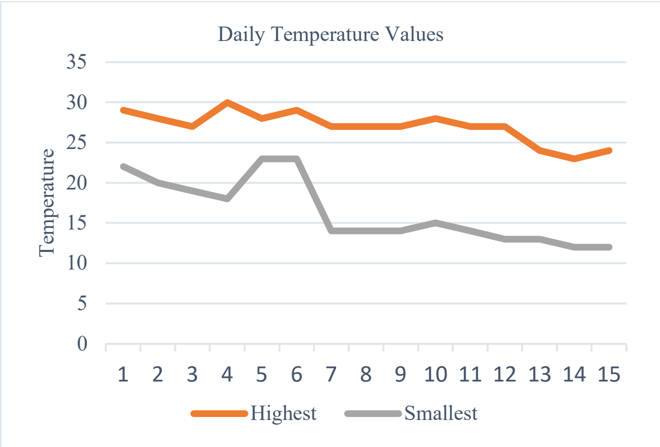


Fig. 7. *Daily highest and smallest temperature*

The temperature changes daily. The humidity level changes depending on the temperature. Temperature and humidity are the two main factors during irrigation. Figure 8 shows the daily moisture level.

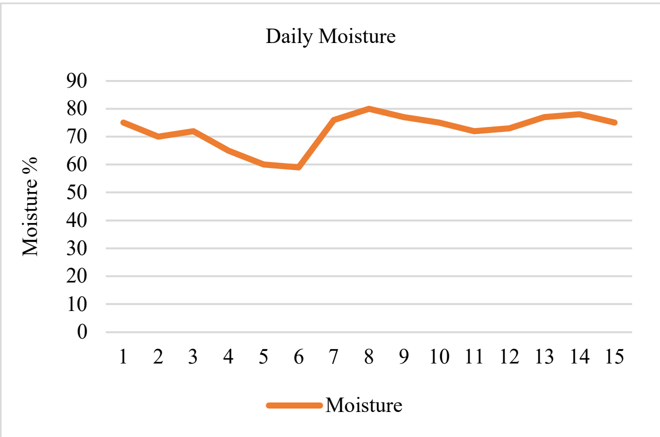


Fig. 8. *Daily moisture*

In my site, irrigation water of each container has been provided from a sized container. Thus, it was determined how much water was used daily. Daily water consumption is shown in Figure 9.

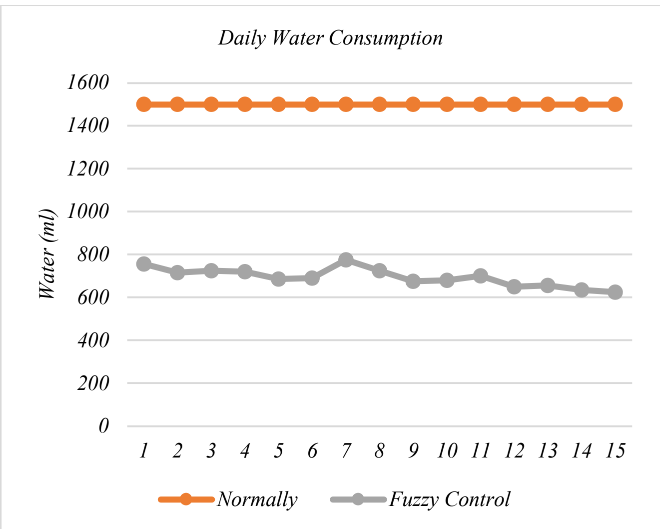


Fig. 9. Daily water consumption

IV. DISCUSSION

The study covers a period of fifteen days. These days, different temperature and humidity values have occurred. The temperature varied between 24 and 31 degrees at the highest. The lowest was 12 degrees. Humidity values vary between 60 and 80. For irrigation, outdoor temperature and humidity are as important as soil moisture. In parallel with the increase in the outdoor temperature, the irrigation water should increase. Decrease in the outdoor temperature will decrease the evaporation and will cause a decrease in the irrigation water. Likewise, an increase in outdoor humidity means a decrease in irrigation water.

In the study, tomato seedlings grown in two different environments were compared. Normal irrigation was done in the first tomato seedling. In the second seedling, the irrigation system was carried out with fuzzy logic control. For fuzzy logic control, simulation was first done in MATLAB. According to the simulation results, code was written with Arduino microcontroller. Irrigation was done with this code. At the same time, remote monitoring is provided.

In the first seedling growing, daily constant irrigation was applied. Watered with 1500ml of water daily. Irrigation value changes daily in the second seedling growing. Some days it is 900 ml, sometimes this value decreases to 600 ml. The main reason why these values vary so much; is the change in outdoor temperature and humidity values. In a second important factor; is soil moisture. As the moisture values in the soil increase, the irrigation water decreases. Since the moisture values in the soil were low in the first days, the irrigation values were high. As the soil is irrigated, the need for irrigation water decreases when the soil moisture values increase.

V. CONCLUSION

With unconscious irrigation, some soils become barren and some cannot be irrigated. With the work carried out, an efficiency of 53.77% has been achieved in irrigation water in seedling cultivation. In addition, the human factor, which is the biggest risk in irrigation, has been minimized. It has been automated with the irrigation system that varies from person to person. Irrigation was carried out with fuzzy logic control with a sensor coming from temperature, humidity and soil moisture. Thus, adaptation to the ambient conditions was achieved quickly. In addition, the data from the sensors could be monitored instantly with remote access.

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Authors' Contributions

The authors' contributions to the paper are equal.

Statement of Conflicts of Interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

The authors declare that this study complies with Research and Publication Ethics

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